STRATEGIES FOR THE EFFECTIVE UTILISATION OF SMALL RUMINANTS AND FEED RESOURCES IN THE HIGHLANDS OF ASIA

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ABSTRACT

The paper discusses possible strategies for the effective utilisation of small ruminants and feed resources in the highlands in Asia. These strategies are justified by inadequate feed resources, inefficient feeding systems and continuing low productivity. A major constraint is accessibility to the available feeds particularly by transhumant flocks of both goats and sheep. Alleviating these problems and improving the efficiency of the production system should address the following objectives:

(1) Identification and definition of the feed resources,
(2) Assessment of nutritive value,
(3) Inclusive in efficient and economic feeding systems and
(4) Utilisation with predictable (optimal or potential) production; these components are discussed in detail.

Attention is drawn to the metabolisable energy (ME) system which is the most widely used presently and also digestible crude protein (DCP). The latter is of three categories : rumen degradable protein (RD), undegraded dietary protein (UDP) and undigested UDP. The strategies for increased productivity include *inter alia* : increased forage cultivation and utilisation, increased use of dietary nitrogen sources, strategic use of supplementary protein sources including the use of urea-molasses block licks, breeding to increase numbers and more use of intensive stall feeding systems. These together should provide for more efficient use and increased contribution by the goat and genetic resources in the highlands of Asia.

I. INTRODUCTION

The highlands of Asia, with focus on the Hindu Kush-Himalayan region, are an area of extreme contrast and diversity. The region consists of mountains, hills and plateaus of Afganistan, Bangladesh, Bhutan, Burma, China, India, Nepal and Pakistan. The elevations range between 150 to 8880m and the average altitude exceeds 4000m for the entire range (Maharjan *et al*., 1987). Most of the animal activities occur in the middle hill and high mountain region up to 2500 m.

The range as a whole is characterised by the complexity of climate, vegetation, human and animal components and their interactions. This complexity manifests in differences in farming systems appropriate to the different ecological zones and the density of human populations in these parts. Both the complexity of the systems, as well as the sparse base of knowledge on the management of the available resources has called for increased attention on the development of this region, including the more effective use of the ruminant resources which can be identified with their current importance and future potential.

With the complex Hindu Kush-Himalaya region, ruminants are thriving resources within the farming systems, fully adapted to the area and serving a variety of important functions. These include buffaloes, cattle goats, sheep, donkeys, yak and chauri. This paper will only be concerned however, with the efficiency of utilising the small ruminants and the feed resources. In particular, it will discuss the significance of nutrition on increased productivity from goats and sheep in the highlands of Asia. For purposes of this paper, the highlands are defined to include the midhill and very high altitude regions.

II. THE SMALL RUMINANT RESOURCES

Due to the large highland area covered across several countries, it is not possible to provide comprehensive statistics on the size of the ruminant populations. For Nepal, it has been estimated that in terms of livestock units, (LU), the high mountains accommodated 1,288 LU which was 12% of the total size of the total ruminant populations (Agriculture/ Forestry Report, 1986).

Table 1 summarises the principle functions of herbivores in the highland regions. It is clear that ruminants play a variety of most important functions in highland regions in the service to man with primary, secondary and miscellaneous functions.

The cattle are mainly the zebu type, but the influence of several types especially from the Indian sub-continent is apparent. In Nepal, the cattle of the terai have a strong influence of the Hariana breed with bulls weighing 300-375 kg and cows 200-250 kg. In the middle mountains, the small Black Hill zebu is conspicuous with live weights of 220-250 kg for

TABLE 1. FUNCTIONAL VALUE OF RUMINANTS AND EQUINES IN THE HIGHLANDS

Species	Primary	Secondary	Miscellaneous
Milch Buffaloes	Milk	Draught	Dung, skin, recreational and cultural
Water Buffaloes	Draught	Meat	Dung, skin, recreational
Cattle	Meat/Milk	Draught	Dung, skin, recreational and cultural
Goats	Meat	Milk/Fibre+	Skins, hair, dung, recreation
Sheep	Wool/Mutton	Milk	Skin, dung, recreational and cultural
Donkeys	Draught		Dung
Horses	Draught	Meat	Dung
Mules	Draught		Dung
Yaks/Chauri	Draught	Milk	Hair and hides

+ Mohair, pashmina (cashmere) and coarse wool bulls and 120-150 kg for cows. In the high hills, this size is even smaller presumably due to an adaption to very cold temperatures and severe environmental conditions, with corresponding live weights of 160-200 kg and 120 kg for bulls and cows respectively. The larger and faster growing animals are usually castrated, resulting in a gene pool of poorer quality animals which are low producing.

Among the ruminants, goats and sheep are particularly important animals as they are widely owned by small farmers. It is appropriate to briefly consider the small ruminant resources. Table 2 identifies and summarises the names of the more important goat and sheep breeds in the highlands of Asia. At least 9 breeds of goats and 11 breeds of sheep are presently known. Unfortunately, there are inadequate statistics on total populations of goats and sheep in the highlands.

(1) Goats

Goats are widely distributed throughout the highlands and form part of the migratory flocks, usually with sheep. Both species are components of transhumance systems in the highlands.

The breeds are generally larger in the highlands compared to the lowlands. In Nepal, several genotypes are identifiable : southern hill goat in the Siwalik and Mahabarat ranges called Khari, sinhal goats of the high mountains and Changra goat of the Mustang district, north of the Annapurna range. In the trans-Himalayan regions, there exists the Changra also called the Tibetan, which is particularly useful for pashmina and cashmere production. These goats are also valued for meat production. Pradhan (1987) has recently categorised the ecological distribution of the different sheep and goat breeds in Nepal and this is reproduced in table 3. It can be seen that the middle hill to the Trans-Himalaya region, have about 67% of the sheep and 14% of the goat populations.

(2) Sheep

The sheep breeds of significance in the highland areas are the Bhanglung of Tibetian origin in the trans-Himalayan region, Barwal or Jumli in the high mountains and middle hill areas and the Kage in the lower hills (table 3). Of these, the Barwal and the Kage are the most important breeds in Nepal and have also been used for crossbreeding (Kharel and Pradhan,

TABLE 2. IMPORTANT GOAT AND SHEEP BREEDS IN THE HINDU KUSH-HIMALAYAN HIGHLANDS

Breed	Country	Speciality	Approximate adult live weight of female (kg)
		GOATS	
Buchi	Pakistan	Meat, milk	22
Changra	Nepal	Pashmina, cashmere	20
Changthangi	India	Meat, milk	19
Chigu	India	Pashmina	26
Gaddi	India	Meat, milk	24
Khari	Nepal	Meat, milk	25
Labri	Pakistan	Milk, meat, hair	35
Shurri	Pakistan	Milk, meat	30
		SHEEP	
Barwal	Nepal	Wool, mutton	30
Bhanlung	Nepal	Wool, mutton	25
Changthangi	India	Wool	34
Gaddi	India	Wool, mutton	26
Gurez	India	Wool	29
Kail	Pakistan	Wool, mutton	35
Kage	Nepal	Wool, mutton	18
Karnah	India	Wool	33
Poonchi	India	Wool, mutton	28
Poonchi	Pakistan	Wool, mutton	30
Rampur Bushair	India	Wool	25

TABLE 3. ECOLOGICAL DISTRIBUTION OF DIFFERENT BREEDS OF SHEEP AND GOATS IN NEPAL
(Pradhan, 1987)

Ecological region	Altitude (m)	Climate	Sheep Breed	Sheep No. (%)	Goat Breed	Goat No. (%)	Management system
Trans-Himalaya (behind Himalaya mountain range)	more than 2500	Temperate	Bhanglung (Tibetian)	30,000 (3.8)	Changra (Pashmina, Cashmere)	47,000 (1.0)	Sedentary and transhumance
High mountain	more than 2500	Temperate-alpine	Barwal (Jumli)	321,863 (41.0)	Sinhal	100,000 (2.0)	Transhumance
					Sinhal, high-hill goat	608,425 (12.5)	
Middle hill	1500-2500	Temperate	Barwal	173,551 (22.1)	Sinhal	55,000 (1.1)	Transhumance
Lower hill	300-1500	Subtropical	Kage	162,253 (20.7)	Khari (local hill)	2,744,177 (56.2)	Sedentary
Terai	less than 300	Subtropical, tropical	Lampuchhre (Lohia)	97,385 (12.4)	Terai (crossbreeds)	1,327,733 (27.2)	Sedentary moving
TOTAL				**785,052**		**4,882,335**	

1986). The Kage is very popular with the farmers because of its high prolificacy (Pradhan, 1986).

The Bhanglung is a very hardy sheep breed and very well adapted to the harsh climates in high altitudes of the Tibetan plateau. Adult ewes weigh about 25 kg and rams 35 kg. The breed has a restricted breeding season in September- October and an annual wool clip of 1-1.5 kg/head.

The sheep, like goats are stationery or migratory and are associated with transhumance systems. Both goats and sheep are valued for their meat and also draught capacity. While pashmina or cashemere is the main fibre of economic importance produced by goats, wool is the main product from sheep. Both goats and sheep are also valued for their manure. Flock sizes are variable: small flocks of about 20 animals, medium size flocks from 100-500 animals, and the more wealthier farmers have up to 4000 animals. Usually sheep comprise 30-40% of the flock.

Transhumant movements occur in the forests and near villages and move to alpine pastures with spring. Usually, the goat and sheep flocks move north during the spring and return south during autumn, travelling around 300 km per year. The descent from the highland areas begins with the onset of lower temperatures in winter and to the winter pastures situated in the middle mountains at altitutes of 800-2000m. In the annual cycle, all the available vegetation in the tropical and alpine levels are utilised. The winter grazing are found in the subtropical and tropical zones (500-1000m), whereas the summer pastures are found close to the alpine zones.

In their yearly cycle, the goat and sheep flocks spend 315 days in the forest, 35 in the high pastures and only 15 days in fallow lands of the cultivated zone. This pattern implies that 80% of the feed requirements in terms of fodder comes from the forests, emphasising the importance of fodder trees and shrubs (Alirol, 1986).

III. COMPARATIVE NUTRITIONAL DIFFERENCES BETWEEN GOATS AND SHEEP

The comparative differences between goats and sheep have recently been summarised (Devendra, 1986) and are presented in table 4. It is emphasised that the list is by no means complete, implying that there probably also exist many other differences. However, the list does provide

TABLE 4. COMPARATIVE DIFFERENCES IN THE NUTRITION BETWEEN GOATS AND SHEEP
(Devendra, 1986)

Characteristic	Goats	Sheep
1. Activity	Bipedal stance and walk longer distances	Walk shorter distances
2. Feeding pattern	Browser, more selective	Grazer, less selective
3. Browse and tree leaves	Relished	Less relised
4. Variety in feeds	Preference greater	Preference lesser
5. Taste sensation	More discerning	Less discerning
6. Salivary secretion rate	Greater	Moderate
7. Recycling of urea in saliva	Greater	Lesser
8. Dry matter intake :		
- For Meat	3% of B.W.	3% of B.W.
- For Lactation	4-6% B.W.	3% of B.W.
9. Digestive efficiency	With coarse roughages higher	Less efficient
10. Retention time	Longer	Shorter
11. Water intake/unit DMI	Lower	Higher
12. Rumen NH_3 concentration	Higher	Lower
13. Water economy	- More efficient	- Less efficient
- Turnover rate	- Lower	- Higher
14. Fat mobilisation	Increased during periods of feed shortages	Less evident
15. Dehydration		
- Faeces	Less water loss	Relatively higher water loss
- Urine	More concentrated	Less concentrated

the main distinguishing features between the species, based on an understanding of the present state of knowledge.

Some of the main differences are worth emphasising. These include in the goat, the bi-pedal stance, relatively higher activity, preference for more variety in feeds, and more selective and browsing tendencies compared to sheep. Other differences are related to taste, water economy, dehydration, salivary secretion, recycling of urea and digestive efficiency. Concerning the latter, it is not known with any certainty if real differences do exist in the utilisation of very fibrous feedstuffs although present evidence does seem to suggest that goats do utilise coarse roughages much more effectively than do sheep. Thus, the value of goats increases with decreasing quality of grazing and available feeds. There is a need for lot more information on this issue and a better understanding of the several interacting factors inter alia : feed particle size, amount of salivary secretion, rumination, concentration of cellulose splitting micro-organisms, fermentation rate, absorption capacity, water turnover, recycling of urea, rate of passage and retention time (Devendra and Burns, 1983).

Recently, attention has been drawn to the higher NH_3N in goats which has been attributed to greater rumen protein degradation as a result of a longer retention time of digesta in the rumen (Watson and Norton, 1982). Since goats drink less water than sheep per unit dry matter intake (Gihad 1976; Gihad, El-Bedawy and Mehrez, 1980; Owen and Ndosa, 1982 and Alam, Poppi and Sykes, 1983), it has further been suggested that the lower water intake may be the cause of the higher rumen NH_3N concentration (Alam *et al*., 1984).

V. THE UTILISATION OF THE FEED RESOURCES

A specific focus on the available feed resources and their utilisation of the feed resources is particularly important since the feed requirements are presently inadequate. In Nepal for example, there is an acute feed shortage in the mid-hills (Rajbhandary and Shah, 1981).

In order to alleviate the prevailing situation and increase the effective utilisation of the feed resources, the following objectives are considered essential :

(1) Identification and definition of the feed resources.
(2) Assessment of nutritive value.
(3) Inclusion in efficient and economic feeding systems,
(4) Utilisation with predictable (optimal or potential) production.

(1) Identification and definition of feed resources

The assessment of the feed resource base should seek to identify and clearly define the different types of feeds available within a particular situation, district, state and the country as a whole. Essentially, a feed inventory of all available feeds needs to be produced as completely as is feasible. This point has also been stressed for Nepal (Yazman, 1986). The inventory should identify and then quantify the feeds produced by considering *inter alia* the following aspects :

(i) Quantities and kinds of materials produced throughout the year. This involves the use of statistical data and other sources of information for example, area of the crop, average yield per hectare and extraction rates. These ancillary data need to be defined. Where assumptions are used these also need to be stated.
(ii) Brief physical description (eg. bulky, roughage, slurry, wet or dry).
(iii) Location of production.
(iv) Seasonality of production.
(v) Present use by animal category.
(vi) Alternative uses if any (eg. as fertiliser).
(vii) Potential for processing.
(viii) Cost of collection, handling, transportation and processing.
(ix) Potential utilisation in prevailing feeding systems.

For purposes of classification, five broad groups of feeds are identified :

(i) Forages (Grasses, legumes and leaves).
(ii) Energy and protein concentrates.
(iii) Crop residues.
(iv) Agro-industrial by-products, and
(v) Non-conventional feeds.

The first group includes all types of grasses, shrubs and legumes that are of potential value to animals. Examples are elephant or Napier grass (Pennisetum purpureum), Guinea grass (Panicum maximum), cassava leaves (Manihot esculenta Crantz) and leucaena (Leucaena leucocephala).

Included in ~~this~~ category are the various types of feeds from forests, and which represent the main source of nutrients for animals in the highlands. In the highlands, these feeds often represent the only source of green forage during summer and winter for goats and sheep. Winter grazing is usually done in oak forests and Quercus semecarpifolia provides very valuable feed.

Energy and protein concentrates include such energy sources as the cereals (maize, wheat and barley), root crops like cassava and sweet potatoes and also fats such as tallow, lard and palm oil. The protein concentrates refer mainly to fish meals, oil seed meals and cakes, for example soyabean meal and cottonseed cake.

Crop residues and agro-industrial by-products constitute a group which is very important in most countries, and which are probably also underutilised. By virtue of being indigenous and therefore traditionally used, the potential value rests in not only reduced cost of production, but also the possibility that their intensive use can encourage possible expansion of components of the animal industry. In recent years therefore, this group has been the focus of wide and concerted research effort throughout the Asian region. The best example of this is seen in the efforts to increase the utilisation by ruminants, of rice straw after urea or ammonia treatment or by microbial degradation to improve the nutritive value or supplementation with various green proteinaceous forages.

Crop residues are produced from crop growth and production and are usually fibrous materials. They are usually referred to as agricultural by-products. Agro-industrial by-products on the other hand, are feed materials that are produced usually from agro-based industries on a commerical basis. The crop residues are particularly suited for utilisation by ruminants (buffaloes, cattle, goats and sheep) usually at the farm level. The differences between the two types of feeds are mainly due to nutritive quality, with crop residues being deficient in energy, nitrogen (protein) and micro-nutrients and agro-hndustrial by-products generally having higher contents of each of these nutrients.

The fifth category, non-conventional feed resources include all those types of feeds that are not traditionally used by animals. By definition, non-conventional feed resources (NCFR) refer to all those feeds that are not traditionally used in animal feeding and or not normally used in commerically produced ratios for livestock. NCFR include feeds from animals, annual and perennial crop production and also residues and wastes from animal sources and the processing of food for human consumption.

It has been estimated that in Asia and the Pacific, NCFR account for approximately 194.1 x 10^6 tonnes which is about 45% of the total availability from field and plantation crops. Approximately 80% of the NCFR is field crops and 93% of the feeds in tree crop cultivation (table 5) are principally suited for feeding ruminants.

Crop residues, agro-industrial by-products and NCFR are essentially of three categories :

(i) Energy rich feeds (eg. bananas, citrus fruits and pineapple wastes).
(ii) Protein supplements such as oilseed cakes and meals, by-products of animal processing (eg. feather meal and poultry litter), low quality pulses and fishmeals.
(iii) By-products from cereal milling and milk processing.

(2) Assessment of nutritive value

The assessment of nutritive value aims at establishing a clear understanding of the nutrients available in the feed, the extent of this availability in metabolic terms and the attractiveness of the feed to animals. With protein sources, quality is particularly important. The following procedures are important :

(i) Proximate analyses (to include minerals)
(ii) In vitro digestibility
(iii) *In vivo* digestibility
(iv) Toxic components
(v) Amino acid profiles

TABLE 5. THE AVAILABILITY OF NON-CONVENTIONAL FEED RESOURCES IN ASIA AND THE PACIFIC (Devendra, 1985)

Category	Availability (10^6 tonne)
Field Crops	189.9
Tree Crops	4.2
Total	194.1$^+$

$^+$ Represents 44.9% of the total availability from field and plantation crops.

The feed should have some chemical description, in particular, nitrogen, neutral-detergent fibre and ash contents. If a crop residue is to be fed, in addition to the chemical description, it will be useful to know the variety, stage of maturity and any processing particulars (eg. chopping). Amino acid profiles apply only to protein concentrate feeds.

The assessment of digestibility enables the determination of digestible energy (DE) and metabolisable energy (ME). It is also possible to calculate the nutritive value of the feed based on the proximate analyses data. The following expressions of energy value are in use :

(i) Starch equivalent (SE) - United Kingdom
(ii) The Scandinavian Fodder Unit (SFU) - Denmark
(iii) Fattening Fodder Units (FFU) - Denmark
(iv) The French system of Fodder Equivalents - France
(v) Rostock NEF system - Germany
(vi) Net energy of lactation system - Netherlands.
(vii) California system - USA
(viii) Total digestible nutrients (TDN) - USA
(ix) Metabolisable energy (ME) - United Kingdom
(x) Digestible energy (DE) - United Kingdom

Alderman (1983) has reviewed the status of the newer European feeding systems and concluded that ME values was basic to all systems. Thus of the systems in use, the ME system is the most widely used presently. It has become the preferred expression of feed value (MAAF, 1975; van Eys, Vermorel and Bickel, 1978; ARC, 1980; Sibbald, 1982, Dewhurst, et al., 1986) since the deduction of energy losses in urine and fermentation gases from DE provides a more accurate estimate of productive energy. ME can be calculated from DE from the equation ME = 0.81 DE based on methane and urine energy as a constant fraction (Armstrong, 1964).

With forages, considerable effort has been directed at predicting ME from particularly in vitro and to a lesser extent vivo measurements. The use of the former is however contrained by large systematic errors when applied to data sets other than these used to derive them (Barber, Adamson and Altman, 1984). Consequently this is limited in practical use. These authors have suggested that a more accurate prediction of ME would be based on apparent *in vivo* digestibility of their proximate constituents (crude protein CP, crude fibre CF, ether extract EE and nitrogen-free extract (NFE) using the following equation :

$$ME\ (MJ/kg\ DM) = a\ DCP + b\ DEE + c\ DNFE + d\ DCF \quad \text{----------}(1)$$

where a, b, c, and d are constants and D indicates digestible nutrients all measured in g/kg.

Equation (1) assumes that *in vivo* work is required, but this is not always feasible simply because of cost of running such experiments. A more practical solution, and one which is used widely for forages, is the prediction of ME from *in vitro* DMD values using the equation proposed by the MAAF (1975) in the United Kingdom :

$$ME\ (MJ/kg\ DM) = 0.15\ (0.98\ DMD\% - 4.8) \quad \text{------------------}(2)$$

The use of (2) enables the determination of ME in individual forages and the extent to which they can support the requirements for maintenance, growth, pregnancy and lactation. When the available ME content is related to nutrient recommendations, it also enables calculations of supplemented energy that is required to sustain production, such as in high producing dairy goats.

With respect to proteins, the following indices are used to describe quality :

(i) Digestible crude protein (DCP)
(ii) True protein (TP)
(iii) Protein efficiency ratio (PER)
(iv) Gross protein value (GPV)
(v) Protein replacement value (PRV)
(vi) Biological value (BV)
(vii) Biological assays
(viii) Protein equivalent (PE)
(ix) Degradability

Of these indices, DCP and BV are used very widely. Recently, increasing use is also being made of protein degradability in the rumen.

(3) Utilisation in efficient and economic feeding systems

Once a feed has been identified and there is adequate information on nutritive value, the next step is an assessment of its value in feeding systems. The following aspects are considered essential for this assessment:

(i) Voluntary intake (specifying animal species and level of feeding).

(ii) Digestibility coefficients (specifying animal species, level of feeding, supplementation and any processing).

(iii) Feeding trials which specify the proportion of the feed incorporated and relate this to predictable responses and,

(iv) Any observed side effects eg. off flavours or toxic influence.

Animal performance is usually measured by such parameters as feed efficiency, growth rate, milk or fibre production.

(4) Utilisation and predictable (optimal or potential) production

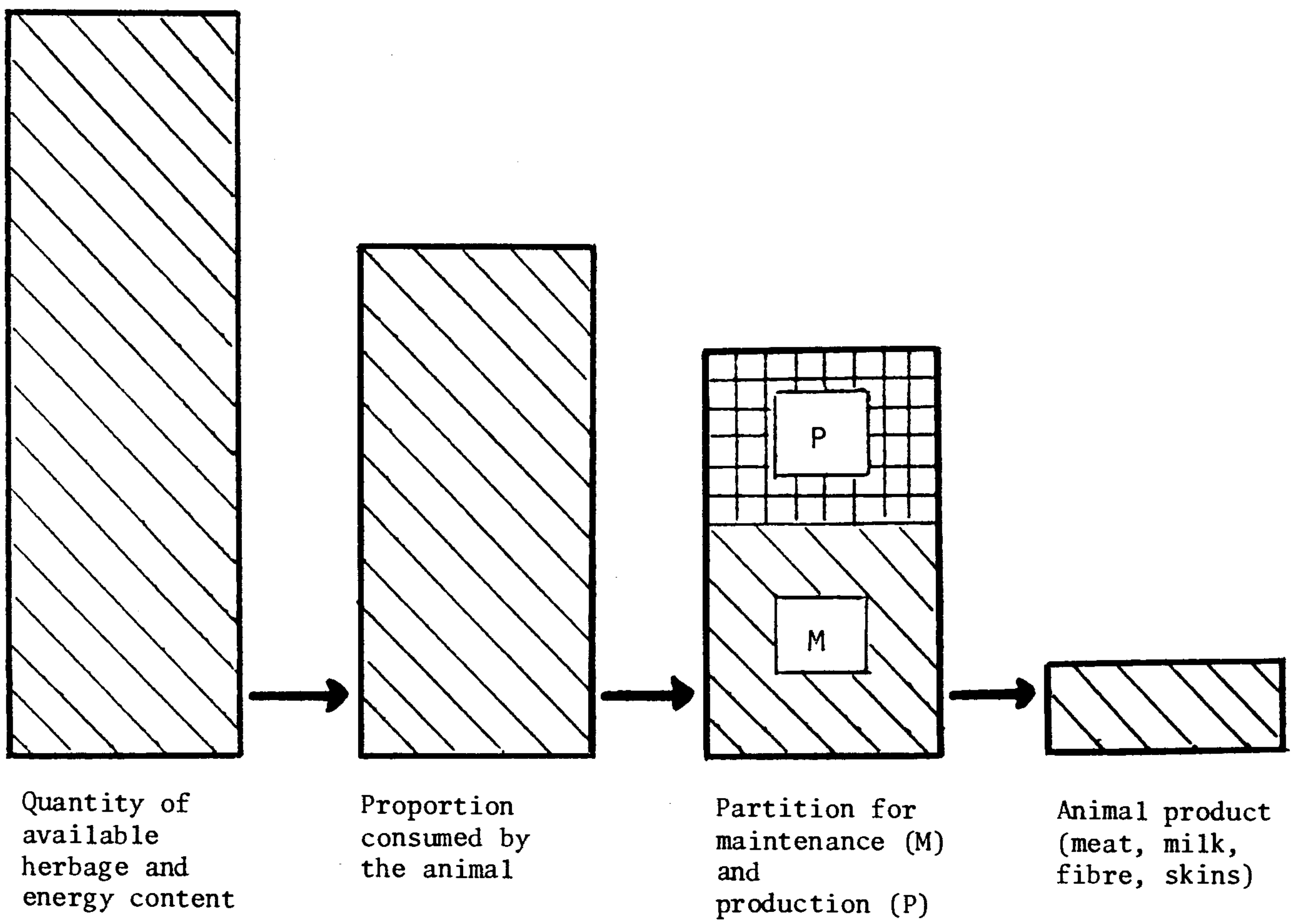
(i) Voluntary feed intake

An essential prerequisite for good performance is maximum voluntary feed intake (VFI). The net energy (NE) absorbed each day is controlled by three different but related parameters (Minson, 1985), and are the quantity of food eaten (I), the proportion of each unit of feed that is digested (D), and the efficiency of the products of digestion (E). This is represented by the equation $NE = I \times D \times E$. With herbage for example, the manner in which the energy is utilised by ruminants is illustrated in Figure 1. The intake is regulated by interactions between metabolic processes in the tissues and the transactions that occur in the reticulo-rumen (Weston, 1984). The level of intake is governed by the amount of material in the reticulo-rumen, its rate of digestion and the rate of digestion out of the reticulo-rumen.

The degree of lignification in the fibre represents the main barrier to intake and digestion even if protein, minerals and vitamins are adequate. In order to overcome this, physical, chemical and biological treatments have been attempted with crop residues, of which chemical treatement especially with urea-NH_3 treatments appear to be particularly promising.

FIGURE 1

THE EFFECTIVE CONVERSION OF AVAILABLE ENERGY IN HERBAGE



(ii) Dry matter intake

Considerable variation in VFI intake are apparent between and within tropical grasses. Some of the differences are due to differences in digestibility, but other unrelated factors such as those recorded for *Panicum* varieties may be involved (Minson, 1971a). Rate of decrease in digestibility of younger tropical herbage is as high for temperate species (Minson, 1971). It has also been shown that the decline in digestibility with age of tropical grasses was more rapid than tropical legumes which retained relatively high digestibilities at maturity (Milford and Minson, 1966). Differences *in vitro* digestibility have been reported between genotypes of *Digitaria* (Strickland and Haydock, 1978).

In view of rapid growth of herbage in tropical areas and variations in nutritive value, it is essential that to achieve high digestibilities and therefore VFI, grasses be used at an optimum stage of growth. In general, it is rarely possible to achieve digestibilities beyond 70%. In practical terms, adult ruminants (save the dairy goat) are unlikely to consume beyond 8% of their live weight as fresh grass for digestibilities of mature forage of the order of 40%.

Apart from the disadvantage concerning the restriction of energy uptake imposed by the bulk of tropical grasses, it is distinctly also possible for DMI to be limited by the feed-water content of, or the free-water on the ingested herbage, especially in the humid tropics. In the West Indies, for example, the dry matter content of herbage during the wet seasons was very low as in Pangola grass (Butterworth, Groom and Wilson, 1961) with a dry matter content of 23.4% compared to 39.3% in the dry season such that the herbage contributes a high proportion of the total water consumed. Similar observations have also been made in Thailand (Holm, 1973). Inadequate dietary energy arises from reduced DMI and is likely to occur when the dry matter content falls below 25%.

(iii) The significance of digestibility

A primary cosideration concerning DMI is digestibility. Digestibility of a feedstuff is affected by state of maturity of the crop, botanical composition, dry matter intake and dietary supplements, processing and chemical treatment. In general, ruminants eat more of a feedstuff the more digestible it is (Blaxter, 1962), so that high digestibility increases DMI. Increasing digestibility means that a higher proportion of the food is absorbed and digestion is more complete, with the end products of digestion the volatile fatty acids (VFA), showing a lower proportion of acetic acid the lowest and energetically least useful VFA, and higher proportion of the more useful acids : propionic and butyric acids.

The significance of digestibility becomes more apparent by the demonstration that the efficiency of utilisation of DOM eaten (OM intake x digestibility) increases as the feedstuff becomes more digestible (Armstrong, 1964). Up to 60 to 70% digestibilities, increasing digestibility encourages increasing DMI and increasing efficiency of utilisation of the VF constituents.

(iv) Dietary protein

Of the limiting nutrients, protein is the most critical. Dietary protein is of three categories : (1) rumen degradable protein (RD) which is used for microbial protein synthesis, (2) undegraded dietary protein (UDP) which escapes digestion in the rumen and is absorbed in the small intestines, and (3) undigested UDP which escapes fermentation and absorption in the intestines. The RDP requirements are considered to be 30 g N/kg of organic matter apparently digested in the reticulo-rumen (A.R.C., 1980). It has been estimated (Leibholz and Kellaway, 1984) that the minimum required crude protein of a poor quality diet with a digestibility of organic matter of 50% would be between 6.1-7.4%. With most crop residues with low nitrogen content, and especially cereal straws with 4% crude protein, protein supplementation is clearly necessary.

The protein content of tropical forages is in general low (French, 1957; Bredon and Horrell, 1961; Butterworth, 1967). The protein content falls rapidly with growth and reaches a low level before flowering. During the dry season, the crude protein levels fall to very low critical levels, even below 7% in the dry matter.

The level of protein in the diet affects voluntary intake of food (Campling, Freer and Balch, 1962; Blaxter and Wilson, 1963; Elliott and Topps, 1963) and low protein diets are not readily eaten by ruminants. In sheep, a 7% crude protein level limits intake. The value of an optimal level of dietary protein is therefore obvious as it has a stimulating effect on feed intake and digestibility of energy (Smith, 1962; Elliott and Topps, 1963).

V. STRATEGIES FOR INCREASED PRODUCTIVITY

There are a number of strategies that can be pursued to achieve increased production. Essentially, these relate to improved animal performance, increased numbers of small ruminants and more intensive stall feeding systems. These aspects are briefly discussed below. Aspects related to improved nutrition and the effective utilisation of the feed resources have recently been discussed (Devendra, 1987). One additional issue that is worth emphasising specific to the highland region concerns the need for more precision in relating animal numbers (or ruminant animal units) to more accurate data on quantitative and qualitative aspects of the available feed resources.

(1) Increasing animal performance

Increasing per animal performance especially by more efficient utilisation of the feed resources and improved management should get first priority. Low productivity and high wastage currently represent the most important sources of economic losses in both goats and sheep and this situation needs to be arrested. The overriding factor is improved husbandry practice, through which both goats and sheep can be provided with the opportunity to express their genetic potential to the highland environments to which they are well adapted and in which they serve a variety of useful functions.

(2) Increased forage cultivation and utilisation

Small ruminants and other ruminants in the hill and highland areas depend to a very large extent on forage supplies. Where possible, there needs to be increased forage cultivation. The basic strategy is to produce and use sufficient amounts of feed of good quality that are available all the year round, bearing in mind forest fodders constitute the most important feed base during the summer and winter periods. Forage reserves go a long way towards meeting the nutrient requirements and enable innovative measures to be used to ensure production that can be sustained throughout the year round. Additionally, this also enables adoption of possible conservation measures eg. silage production.

Panday (1982) has recently published available data on the different sources of fodder suited to ruminants, including their nutritive value in Nepal. He indicated that while forests provided up to 90% of the feed supply in some areas, the fodder supply is inadequate and currently aggravated by increased animal numbers, grazing pressure, erosion and decreased production. There are also problems of accessibility and the limited hill forests being intensively used to supply the fodder. For the highland region, Quercus, Symplocos and Castanopsis species are commonly lopped to feed ruminants. For the midhill region, Artocarpus lakoocha, Litsea polyantha, Ficus nemoralis and Ficus lacor are widely fed to ruminants (Joshi and Sharma, 1984). An excellent start has been made by this publication, however, more intensive and expanded fodder cultivation and utilisation of suitable types appropriate to the Hindu Kush-Himalayan region is dependent on more research and development. This is particularly justified in the context of the characteristics of tree fodders and problems unique to their management in highland situations (Heuch, 1986; Robinson, 1986).

An important strategy concerning wider use of appropriate fodder species is to narrow the range of the types used. This can be done by focussing on say 10 varieties within each highland zone, the choice being determined by confirmation surveys within the farms and also by multi-functional value of each species. Once this has been determined, the next approach is to embark on concerted research and development programmes, including all aspects of feeding and utilisation that can stimulate wider use of these, of special benefit to improved animal performance.

More intensive use of forages in feeding systems represents an important means of increasing the utilisation of especially dry roughages. There are several attendent advantages and include :

(i) Easy accessibility on the farm.

(ii) Abundant variety especially in the humid tropics.

(iii) Many are valuable sources of protein minerals and vitamins.

(iv) With some like leucaena (Leucaena leucocephala) a protein source is ensured even during the dry season.

(v) Provide variety in the diet.

(vi) Have a stimulating effect on intake, and

(vii) A laxative influence on the alimentary system.

While there are several examples of forages including a variety of grasses, some of the more important proteinaceous forages include acacia (Acacia spp.), banana (Musa spp.), cassava (Manihot esculenta Crantz), pigeon pea (Cajanus cajan), gliricidia (Gliricidia maculata), sesbania (Sesbania grandiflora) and water hyacinth (Eichornia crassipes). In integrated farming systems, the use of these supplements is clearly of advantage (Devendra, 1983a).

Examples of their use with goats are not extensive, but include cassava leaves with goats in Indonesia (Winugroho and Chaniago, 1983; Soedomo-Reksohjadiprodjo, 1984) and leucaena leaves in the Philippines (Rasjid and Perez, 1982) goats and sheep in Malaysia (Devendra, 1982; Devendra, 1983b).

Forage quality is important in ensuring a high intake of it as well as the base roughage. In some cases, supplements of leucaena to rice straw for example, had little effect on digestibility even when they comprised a significant proportion of the diet (Moran, Satoto and Dawson, 1983), whereas with the others, there was a significant increase in metabolisable energy (ME) intake and nitrogen retention (Devendra, 1983b).

(3) Increasing the use of dietary nitrogen sources

Much more use can also be made of non-protein (NPN) sources which are accessible to most farmers. Of the methods available for NPN utilisation, and prevailing conditions in the highlands, the use of urea-molasses block licks (UMBL) had had considerable success. These two innovations are significant in that they represent two major success stories in Asia.

The value of UMBL is associated mainly with the fact that their attractiveness and taste to ruminant. The blocks are a potentially effective means of making NPN such as urea (15-20%) continuously available, fortified with macro and micro minerals and other nutrients, essential to both the microbes and the animal. The possibility of over-ingestion of the block and the danger of toxicity appears to be remote.

Recently, an attempt has been made to extend the use of UMBL to small ruminants and the three preliminary experiments of Soetanto (1986) in Indonesia are possibly the first of its kind. In experiment 1, the results of digestibility studies with sheep given waffered sugarcane tops (WST) with or without UMBL with 0, 3 or 6% urea and 500g leucaena, indicated that there was an increase in the dry matter disappearance in sacco of waffered sugarcane tops. The results were however, not significant. In experiment 2, four growing lambs were placed on each of three treatments : Control (+ 300g fish meal), WST + UMBL (3% urea) and WST + UMBL (6% urea). The results indicated that UMBL stimulated live weight gain which were significant (Table 6). Experiment 3 was similar to that as experiment 2 and used goats instead. However, it was terminated due to ill health of the goats.

These preliminary studies also suggest that the use of UMBL can also be extended to goats, especially in extensive situations where the feeds are coarse and also sparse. This strategy needs to be substantially expanded in terms of future effort.

(4) Strategic use of supplements

Strategic use of supplements (energy, protein, minerals and vitamins) also merit some consideration. Its economic use needs to be carefully considered especially in relation to breed type and the potential for growth and milk production. Supplements need to be occasionally used for physiological reasons when nutrients are critically limiting. Usually however, they serve a catalytic function in which improved performance is ensured. It is essential that supplementation is economic in terms of response and cost effectiveness in feeding systems for small ruminants.

The requirement for supplements is justified by three particular situations :

(i) Drought feeding where there is a total scarcity of feeds either periodically or long term. This is a common occurrence in many parts of the Near East and Africa.

(ii) Low level of nutrition due to a combination of under-nutrition, poor nutrition, management variables, nutrient requirements and genetically inferior animals. This situation is a common feature throughout the developing countries.

(iii) High producing lactating animals with high dairy merit whose requirements for supplements and good management are maximum.

TABLE 6. THE EFFECT OF UREA-MOLASSES BLOCK LICKS SUPPLEMENTATION ON FEED INTAKE AND DAILY GAIN OF LAMBS IN INDONESIA (Soetanto, 1986)

Diet	DM Intake (g/d)		OM Intake (g/d)		Daily live weight gain (g/day)
	WCT++	UMBL+++	WCT	UMBL	
A+	224.94	88.74	186.27	81.07	-35.40
B	236.64	91.81	209.57	83.87	18.57
C	283.27	116.69	234.15	106.47	23.60

+A - Natural grass *ad lib* + 300 g fish meal
B - UMBL + 3% urea
C - UMBL + 6% urea
++WCT - Waffered sugarcane tops.
+++UMBL - Urea-molasses block licks.

The justification for concentrate supplementation, (mainly energy and protein), is associated with four factors :

(i) Scarcity of nutrients for milk production quantitatively and qualitatively.

(ii) Restrction in energy uptake imposed by bulky roughages.

(iii) Relatively low price of alternative mixed feeds, home grown or purchased concentrates.

(iv) Increased yield (meat or milk) of a monetary value greater than the cost of the feed required to produce it.

(5) Increase numbers

Consistent with improved performance, increased volume of production depends on a very large extent on increasing numbers. This is especially the case with goat meat and mutton which are highly sought after. This relates especially to improvements in reproductive efficiency in which reproductive rate is the all important factor and the build up of numbers is associated with the following factors :

(i) Age at first mating (females)

(ii) Productive life span of males and females

(iii) Annual mortality in the breeding flock

(iv) Number of young females reared per 100 breeding females. This is influenced in turn by :

a) Per cent of breeding females failing to bear

b) Per cent of breeding females producing multiple births

c) Freauency of parturition, and

d) Mortality rate up to first mating

Increasing fertility or number of offsprings born per female per kidding or lambing is important because this influence significantly the margin of profits. Lifetime productivity is essential and thus must be retained in the flocks long enough (5-7 years age) in order that they express their genetic capacity.

(6) Intensive stall feeding systems

More intensive stall feeding systems may be a suitable and important long term solution. While this may be unsuited for the transhumant and nomadic farmers, there are several advantaqes worth noting : control of damage to forests, allows vegetative regeneration, enables maximum use of the manure produced and ensures high animal performance. Additionally, the system could also efficiently utilise family labour, especially of women and children who traditionally manage small ruminants. The stall feeding operation could conceivably be fitted in within the present patterns of production. Intensive stall feeding also has commercial possibilities.

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